PE - 7

ANALYSIS THE MOTION OF OBJECT UNDER THE GRAVITATIONAL INFLUENCE OF THE EARTH

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Abstract

This research aims to study the motion of object under the gravitational influence of the earth and free falling object under the force of air resistance by video analysis with the tracker 4.05. For the first case in this study, the ball is release to the free falling in the bottle with a height of 155 cm and a diameter of 5.5 cm. The results from experiments found that the velocity has increase from 6.06, 1.72, 2.65,3.57 to 4.29 m/s at time of 0.1, 0.2, 0.3 0.4 and 0.5 s, respectively. Comparing the speed from experiment and theoretical analysis showed that only different is less than 5%. For the another case, the ball is release under the force of air resistance with velocity is 5.8 m/s. The results show that the initial of velocity is zero to increasing velocity and velocity is constant at 0.15 m/s. The constant b is equal to 0.053 kg/s.

Key words: gravitational, free falling, tracker 4.05

INTRODUCTION

Physics is based on experimental observations and quantitative measurement. The fundamental laws are expressed in the language of mathematics- the tool that provides a bridge between theory and experiment. Teachers constantly work on improving students understanding of various phenomena and fundamental laws. One of the new creative methods of teaching physics which makes natural sciences more interesting for the students is video analysis using the programs Tracker [1].

Using the program Tracker student can detect the relationship between physical quantities and describe a motion using time dependencies. Tracker offers time dependencies of 22 physical quantities, data processing by means of graphs and tables. From the number of frames per second (30 fps or 120 fps usually) the time is deduced ($\Delta t = 0.033$ s) while the position can be measured in two dimensions (x,y) using a video image after calibration. The function autotracking in this program allows for accurate tracking without mouse. The studied motion can be divided into two parts: the horizontal component and the vertical component. These two components can be analyzed independently of each other and afterwards the results can be combined to describe the total motion.

The student can fit the time dependencies of position, velocity, acceleration and other using a data tool which provides a data analysis including automatic or manual curve fitting of all or any selected subset data. The position and the velocity can be plotted and fitted to see the correlation between the real data and the kinematic equations. For example, student have found that the trajectory of the free fall ball is always a parabola [2].

Digital video analysis using programs Tracker has therefore been continuously improved in term hardware, software as well as contents. This has made video analysis attractive for many 2D and 3D motion experiment including projectile, oscillation, collisions, rotation, Brownian motion, pendulum, rigid body, damping and free falling $[3,4,5]$.

The main goal of this work is analysis the motion of object under the gravitational influence of the earth with the ball release free falling and release under of the air resistance using Tracker 4.05 version.

RESEARCH METHOD

-Preparation of equipment

1. Take plastic bottle with diameter of 5.5 cm and cut the beginning and end of plastic bottle (see fig.1) .

2. Connect the each plastic bottle for length of 2 m and take the hair dryer covered the bottom of plastic (see fig. 2).

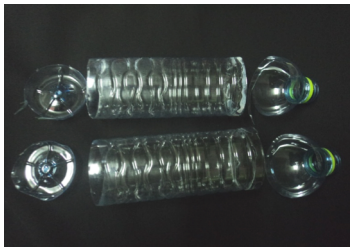

Fig. 1. Plastic trim beginning and end.

Fig. 2. The hair dryer covered the bottom of plastic which glued for length 2 m.

-Experiment

In this reseach , the experiment are divided in two case.

Case 1.: Study the motion of object under the gravitational influence of the earth and free falling

1. Release the ball 0.0008 kg to the equipment (see fig. 3) .
2. Capture picture with video camera.

Case 2. : Study the motion of object under the force of air resistance.

1. Release the ball 0.0008 kg to the equipment and open the air with velocity of 7.7 m/s.
2. Capture picture with video camera.

Fig. 3. The ball is free falling in the equipment.

-Analysis of motion using Tracker

In a typical video analysis, captured and opened a digital video file, calibrated the scale ,and defined appropriate coordinate axes. Fixed position and locked calibration tape of length 2 m. Setting beginning and last frame with frame rate 1/30 s and frame deduced 0.033 s,while the position could be measured in two dimensions (x,y) using the video image after calibration. Using data tool in Tracker which provied a data analysis including automatic or manual curve fitting of all or any selected data, we could fit the time dependencies of the position (Fig. 4).

a b

Fig. 4. Analysis the time dependence of the position of a.) under the gravitational influence of the earth and free falling b.) under the force of air resistance.

RESULT AND DISCUSSION

Case 1.: Study the motion of object under the gravitational influence of the earth and free falling .

In Tracker, when the ball was dropped from height of 2 m .The position of the ball in horizontal displacement (axis in y) in each frame was identified and its displacement at every 0.2 s (axis in x) was shown as a function of time of falling (see fig.5). The result showed that as increas time

,the object move the position in horizontal displacement with slightly different position by average in the rang of 0.015 m .

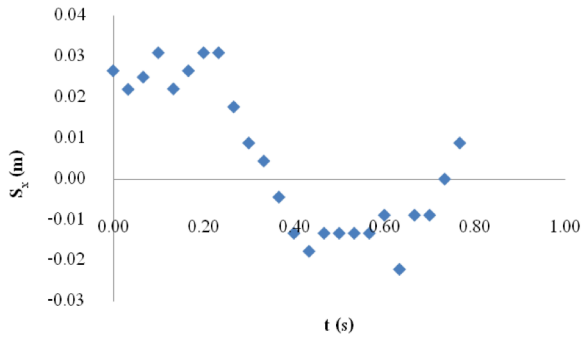

Fig. 5. Position in horizontal as a function of time with free falling.

At the position of the ball in vertical (y) displacement in each frame was shown as a function of time of falling (see fig. 6.). The result showed that as increas time, the object move the position in vertical displacement with increasing distance.

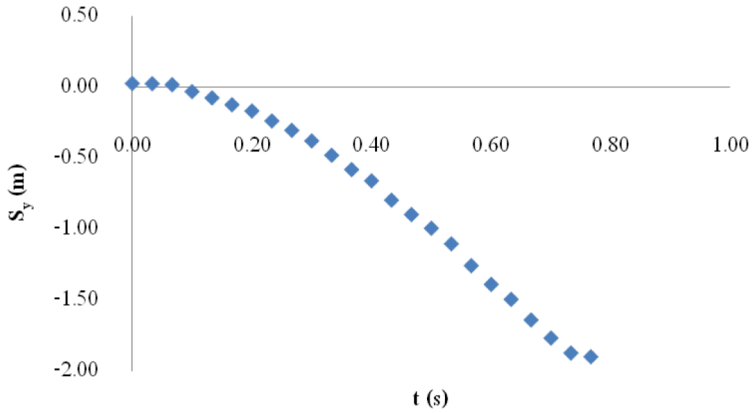

Fig. 6. Position in vertical as a function of time with free falling.

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In fig. 7., showed that with increase of time, the velocity are increasing due to the acceleration of the gravity .

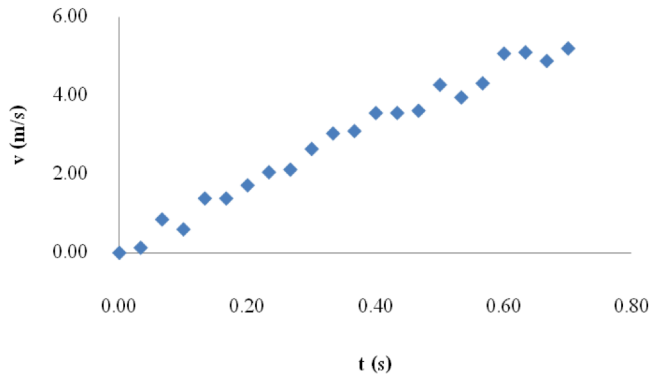

Fig. 7. The variation of v value as a function of time with free falling.

For verification of the results by means of models, we compare real situation (velocity) with mathematical description as follow

$$v^2 = u^2 + 2gh$$

The result showed in table 1. The velocity as function of time are slight different value. The error between theory and model is less than 5%.

Table 1. Compare the velocity as function of time with model and theory. ($g = 9.8$ m/s^2)

vertical displacement (m)	time (s)	velocity (m/s)		Error %
		Model from tracker	Theory	
0.02	0.1	0.60	0.62	3.2
0.16	0.2	1.72	1.77	2.8
0.37	0.3	2.65	2.69	1.4
0.65	0.4	3.57	3.56	0.2
0.99	0.5	4.29	4.40	2.5

Case 2. : Study the motion of object under the force of air resistance.

In fig. 8. showed that the time increasing ,the object move the position in horizontal displacement with slightly different position by average in the rang of 0.013 m .

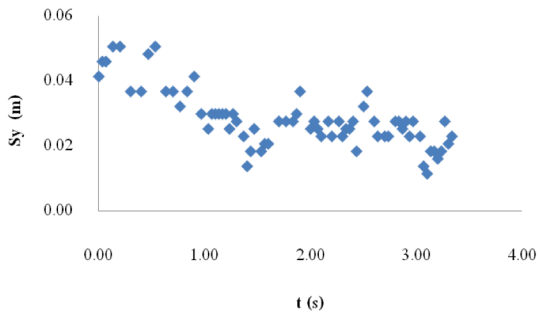

Fig. 8. Position in horizontal as a function of time under the force of air resistance.

In fig. 9. The ball released with the air resistance showed that at the started released the velocity is zero and has increasing velocity at time increase. At time of 1.5 s , the velocity is slightly constant with 5.8 m/s due to balance of resistance force and gravitational force.

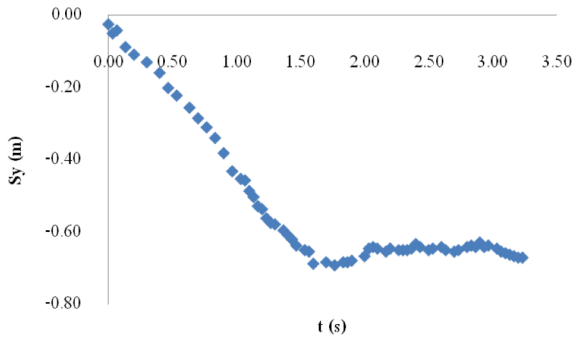

Fig. 9. Position in vertical as a function of time under the force of air resistance.

In fig. 10. Showed that the velocity is increasing with function of time and slightly constant velocity at 0.146 m/s at time of 2 s and could calculate b constant is 0.053 kg/s. Follow equation as

$$mg = -vb$$

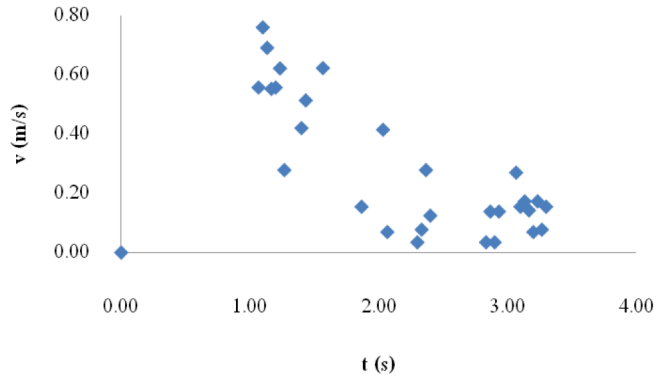

Fig. 10. The variation of v value as a function of time with air resistance.

CONCLUSION AND SUGGESTION

The simple set-up consisting of a digital camera and video analysis open source, Tracker, was used to analysis the motion of falling object. Experimental results were then compared with fundamental equation in mechanics to verify the technique. In this case of free falling , the velocity value of high accuracy was obtained. In the case of air resistance, the velocity is constant at balance force of resistance and gravitation force.

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